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PATENT

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JC15 09/558003

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Sir:

Transmitted herewith for filing is the patent application of:

Inventor: TOSHIKAZU (NMI) HORI; YUTAKA (NMI) HIRONO; RAYMOND J. SIU

For: VIDEO GLARE REDUCTION

Enclosed are:

7 Pages of specification 1 Pages of abstract 5 Pages of claims  
2 Sheets of drawing X formal informal  
X An assignment of the invention to PULNIX AMERICA, INC., submitted with  
separate transmittal  
A certified copy application(s) \_\_\_\_\_  
from which priority is claimed.

CLAIMS AS FILED				
	NUMBER FILED	NUMBER EXTRA	RATE	BASIC FEE \$690.00
TOTAL CLAIMS	12 - 20 =	0	x \$ 18.00	0
INDEPENDENT CLAIMS	4 - 3 =	1	x \$ 78.00	78.00
Multiple Dependent Claims, if any	0		x \$260.00	0

768.00  
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The Commissioner is hereby authorized to charge the filing fee and any additional fees as set forth in 37 C.F.R. 1.16 and 1.17 which may be required or credit any overpayment to Account No. 19-0310. A duplicate of this transmittal is attached.

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Date: 04/24/00

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TOSHIKAZU (NMI) HORI; YUTAKA (NMI) HIRONO

Applicant or Patentee: TOSHIKAZU (NMI) HORI; YUTAKA (NMI) HIRONO and RAYMOND J. SIU Attorney's  
Serial or Patent No.: \_\_\_\_\_ Docket No.: SS-722-07  
Filed or Issued: \_\_\_\_\_  
For: VIDEO GLARE REDUCTION

**VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS  
(37 CFR 1.9(f) and 1.27(c) - SMALL BUSINESS CONCERN**

I hereby declare that I am

the owner of the small business concern identified below:  
 an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF SMALL BUSINESS CONCERN PULNIX AMERICA  
ADDRESS OF SMALL BUSINESS CONCERN 1330 Orleans Drive  
Sunnyvale, California 94089

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.12, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees to the United States Patent and Trademark Office, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention described in:

the specification filed herewith with title as listed above.  
 the application identified above.  
 the patent identified above.

If the rights held by the above identified small business concern are not exclusive, each individual, concern or organization having rights in the invention must file separate verified statement averring to their status as small entities, and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d), or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern or organization having rights in the invention is listed below:

No such person, concern, or organization exists.  
 Each such person, concerns or organizations listed below.

Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

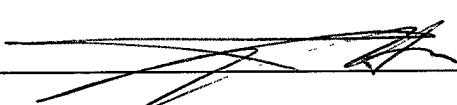
I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING TOSHIKAZU (NMI) HORI

TITLE OF PERSON OTHER THAN OWNER PRESIDENT

ADDRESS OF PERSON SIGNING PULNIX AMERICA, INC., 1330 Orleans Drive, Sunnyvale, California 94089

SIGNATURE  DATE 8/20/2006

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

5 To the Commissioner of Patents and Trademarks:

Your petitioners, Toshikazu (NMI) HORI, a citizen of Japan and a resident of Cupertino, California, whose post office address is 10134 Parkwood Drive, Cupertino, CA 95014-1568; Yutaka (NMI) HIRONO, a citizen of Japan and a resident of San Jose, California, whose post office address is 1184 Fairford Way, San Jose, CA 95129; and, Raymond J. SIU, a citizen of the United States and a resident of San Francisco, California, whose post office address is 33 Santa Cruz Ave., San Francisco, CA 94112, pray that letters patent may be granted to them for a

VIDEO GLARE REDUCTION

20 set forth in the following specification.

## VIDEO GLARE REDUCTION

### 1. Field of the Invention

5 The present invention relates to video cameras, and more particularly to methods and circuits for adjusting the dynamic range of video signals to obtain picture details in the shadows without allowing other areas to glare.

### 10 2. Description of the Prior Art

The typical charge-coupled device (CCD) array can provide as much as 500 mV of dynamic range. But at some point, increasing light levels will not produce increased signal output, because the CCD array will saturate. It is 15 quite common for a CCD array to be followed by a stage of amplification that limits the dynamic output range of the camera to as little as one-tenth of the range possible. Only a small portion of the linear operating region of the CCD array is used. Such amplifiers also bring up the picture 20 brightness to make a more pleasing display. Displays taken directly from the CCD array, or where gains in the amplifier are set low, usually result in pictures that appear too dark.

A user often has to be able to adjust the camera gain to be able to pick out various items-of-interest in a video 25 picture. For example, various lighting conditions and weather changes can change the optimum gain needed to discern license plate numbers in video images obtained by parking lot cameras. An operator has to vary the camera gain in order to see each car's license plate number clearly. This phenomenon 30 prevents automatic recognition systems from operating efficiently, and slows down manually operated systems.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a camera system that can better use the dynamic range 5 of a CCD image array.

It is another object of the present invention to provide a CCD imaging system that is inexpensive to manufacture.

Briefly, a CCD video camera system embodiment of the present invention comprises a CCD imaging device connected to 10 a low-gain amplifier. An analog-to-digital converter converts the analog output of the amplifier to a full-range digital video signal. Such addresses a digital look-up table to produce a digital video output according to one of several 15 selectable range-correction curves. Such range-correction curves comprise two linear slopes that join at one knee or three slopes joined by two knees. Each the linear parts have different gain slopes. The range-correction curves are selected on the basis of the gain slope of the linear slopes, and the knee-points.

20 An advantage of the present invention is that a CCD camera system is provided that can provide increased image details in darker areas of a picture.

Another advantage of the present invention is that a CCD 25 imaging system is provided that can be used in systems that automatically adapt to a variety of lighting conditions and imaging targets.

These and other objects and advantages of the present invention will no doubt become obvious to those of ordinary skill in the art after having read the following detailed 30 description of the preferred embodiments which are illustrated in the drawing figures.

IN THE DRAWINGS

Fig. 1 is a functional block diagram of a camera system embodiment of the present invention; and

5 Fig. 2 is a graph representing the dual-slope transfer functions that can be stored as digital tables in the look-up table of Fig. 1.

10

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A camera system embodiment of the present invention is illustrated in Fig. 1 and is referred to herein by the general reference numeral 100. The system 100 includes a CCD-imaging device 102 that produces a CCD-signal 104. An amplifier 106 set at a relatively low gain by an adjustment 108 helps produce an amplified analog signal 110. An analog-to-digital converter (ADC) 112 produces, e.g., a ten-bit digital video output signal 114. The gain of amplifier 106 is preferably set so that the dynamic output range of CCD 102 matches the digital dynamic range of ADC 112. A look-up table (LUT) 116 converts each digital input word in digital video output signal 114 to a modified word in a system output signal 118, e.g., an eight-bit value. A curve-selection signal 120, e.g., a four-bit digital value, is used to choose which predetermined correction curve inside LUT 116 is to be used. Each range-correction curve comprises two linear slopes that join at a knee and have different gain slopes. The range-correction curves are selected on the basis of the gain slope of the first of the two linear slopes, and the knee-point.

Therefore, the LUT 116 is not used to store the equivalent of a "gamma-correction" curve, which is a

continuous algebraic function and usually implemented with analog techniques. Embodiments of the present invention use only dual-slope compensation conversions that can be precisely controlled with digital techniques and devices.

5 Such also are not continuous algebraic functions, and comprise exactly two linear segments with different gains and joined at a knee-point.

In alternative embodiments of the present invention, the LUT 116 is programmable and downloadable. Such can be useful 10 to load and store the initial look-up tables stored by LUT 116 and selected by signal 120. If LUT 116 is made programmable and downloadable, such can also be useful in applications where the optimum dual-slope compensation conversions need to be empirically derived.

15 For example, a download and reprogramming controller 122 receives new dual-slope transfer functions to load in LUT 116 from a program data signal 124 at a serial input port. The LUT 116 is placed in a reprogramming mode. An address output signal 126 and a selection output signal force an address on the LUT 116 and a data output 130 forces a new write data on the data ports of the LUT 116. For example, the controller 122 can be a flash memory controller and the LUT 116 can be a flash memory device.

Fig. 2 represents a digital transfer function 200 that 25 is preferably embodied in the LUT 116 (Fig. 1). Such LUT 116 can be implemented with a programmable read only memory (PROM), e.g., FLASH memory. In one embodiment of camera system 100, the LUT 116 preferably has a ten-bit input address and an eight-bit data output. Therefore, the digital 30 transfer function 200 is illustrated in Fig. 2 with a X-coordinate that ranges from digital binary 00,0000,0000 at zero to 11,1111,1111 at full scale. Such input produces a transfer function that outputs on the Y-coordinate that

ranges from digital binary 0000,0000 at zero to 1111,1111 at full scale.

A number of selectable transfer functions are shown included in the digital transfer function 200. A straight 5 linear transfer function 202 is included for illustration purposes only. A linear transfer function could be included in LUT 116, but probably would not be used in most applications of camera system 100. A first dual-slope transfer function has a high-gain linear slope 204 that 10 breaks at a knee-point 206 and continues in a lower-gain linear slope 208. A second dual-slope transfer function has a high-gain linear slope 210 that breaks at a knee-point 212 and continues in a lower-gain linear slope 214. A third 15 dual-slope transfer function has a high-gain linear slope 216 that breaks at a knee-point 218 and continues in a lower-gain linear slope 220.

A fourth transfer function is different. A high gain linear slope 215 is needed in the mid-range. It ranges between a pair of knee-points 216 and 217. A pair of lower 20 gain slopes 218 and 219 are used in the extremes of dark and light.

In alternative embodiments of the present invention, three or more knee-points are used and are joined by a multitude of interconnection linear slopes of various gains. 25 It can happen in particular applications that more than one portion of the dynamic range requires high-gain.

The LUT 116 could contain many more such dual-slope and multi-slope transfer functions all selectable by signal 120. Those illustrated in Fig. 2 are simply used to describe the 30 concepts needed for successful implementations.

The lower ranges of the input address and output data in Fig. 2 represent the darker scenes in a digital video image. The increased gains represented by slopes 204, 210, and 216, over linear slope 202, produces video images with enhanced

details. One or more of these may be preferred by a user or automatic image recognition system to pull up details of interest in a particular video frame.

In alternative embodiments of the present invention, a particular one of the dual-slope transfer functions 204-220 5 may be applied to every pixel in a video frame. Or, the dual-slope transfer functions 204-220 may be applied one at a time to sections of a video frame. For example, the top half of a video frame may produce better images for things-of-interest if the dual transfer function 204-208 is selected. 10 But, the bottom half of the video frame may produce better images for things-of-interest if the dual transfer function 210-214 is selected. Of course, the opposite can be implemented wherein the brighter or top-end range has the 15 most gain. In Fig. 2, such would involve knee-points that are below linear slope 202.

Embodiments of the present invention are particularly useful in manufacturing quality control. For example, fine scratches in the surfaces of silicon wafers and chips can be 20 discerned even in the presence of shimmer, glare, and reflections. In the automated manufacturing of glass bottles and containers, cracks and other defects in the glass itself can be spotted even when the lighting conditions are otherwise adverse. In some applications, backlighting needed 25 to candle the pieces can be eliminated. Even sunset lighting conditions that can ordinarily produce impossible glare conditions can be tolerated in automatic vehicle license plate recognition systems.

Some prior art devices apply image processing techniques 30 where the gain of darker or lighter video frames has increased gain, but such do not have the full dynamic range of the original CCD output 104 to work with. Therefore, a large amount of possible resolution is unavailable in such prior art devices.

5 Although the present invention has been described in terms of the presently preferred embodiments, it is to be understood that the disclosure is not to be interpreted as limiting. Various alterations and modifications will no doubt become apparent to those skilled in the art after having read the above disclosure. Accordingly, it is intended that the appended claims be interpreted as covering all alterations and modifications as fall within the true spirit and scope of the invention.

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What is claimed is:

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IN THE CLAIMS

1. A video camera system, comprising:
  - an imaging device with an analog video output
  - 5 having a linear dynamic range;
    - a variable amplifier connected to adjust the analog gain of said analog video output and to produce an amplified analog video signal;
    - 10 receive said amplified analog video signal and for providing a digital conversion in which said linear dynamic range of the imaging device is fully preserved through to a digital video output; and
    - 15 a digital translation table connected to receive said digital video output and providing for a dual-slope output conversion in which a first linear digital gain is applied to a zero-to-middle part of said linear dynamic range of the imaging device, and a second linear digital gain is applied to a middle-to-full-scale part of said linear dynamic range of the imaging device, and having a final digital video output;
    - 20 wherein, image details are rendered more clearly and that would otherwise be lost to view in any low-gain portions of a video image frame.
- 25 2. The system of claim 1, wherein:
  - the digital translation table in which said dual-slope output conversion includes a zero-to-middle part with a single gain greater than one, and a middle-to-full-scale part with a single gain less than one, and such that a knee-point joins them.

3. The system of claim 1, wherein:

the digital translation table in which said dual-slope output conversion includes a zero-to-middle part with a single gain less than one, and a middle-to-full-scale part  
5 with a single gain greater than one, and such that a knee-point joins them.

4. The system of claim 1, wherein:

the digital translation table in which a plurality  
10 of said dual-slope output conversions coexist and are selectable.

5. The system of claim 1, wherein:

the digital translation table in which said dual-slope output conversion is programmable and downloadable.  
15

6. The system of claim 1, further comprising:

a programming and download controller connected to the digital translation table and for providing modifications  
20 to said dual-slope output conversion.

7. A method of video imaging comprising the steps of:

using an imaging device to produce an analog video signal, wherein said analog video signal has a limited linear  
25 operating range between a first magnitude and a second magnitude;

converting said analog video signal linearly to a digital video signal, wherein said digital video signal comprises a limited number of bits that together represent  
30 digital words that range between a third magnitude and a fourth magnitude, and wherein said first magnitude is converted to said third magnitude, and said second magnitude is converted to said fourth magnitude; and

translating said digital words in said digital video signal to a digital video output according to one of two linear amplifications, wherein a first linear amplification exceeds a second linear amplification in gain, 5 and said first linear amplification provides for increased gain in a darker portion of a video image, and said second linear amplification provides for reduced gain in a brighter portion of said video image.

10 8. The method of claim 7, wherein:

the step of translating uses a digital memory device to store a look-up table, and provides for a choice of first and second linear amplification gains.

15 9. The method of claim 7, further comprising the step of:

downloading and programming a new look-up table to replace said look-up table wherein an image detail in said video image is more clearly rendered.

20 10. A CCD video camera system, comprising:

a CCD-imaging device with an analog video output having a linear dynamic range;

25 an analog-to-digital converter (ADC) connected to receive said analog video signal and for providing a digital conversion in which said linear dynamic range of the CCD-imaging device is fully preserved through to a digital video output;

30 a digital translation table connected to receive said digital video output and providing for a dual-slope output conversion in which a first linear digital gain is applied to a zero-to-middle part of said linear dynamic range of the CCD-imaging device, and a second linear digital gain is applied to a middle-to-full-scale part of said linear

dynamic range of the CCD-imaging device, and having a final digital video output;

5 a plurality of said dual-slope output conversions coexistent and disposed in the digital translation table, and that are selectable; and

a programming and download controller connected to the digital translation table and for providing modifications to said dual-slope output conversions;

10 wherein, image details are rendered more clearly and that would otherwise be lost to view in any low-gain portions of a video image frame by increased gain provided by the digital translation table and a conservation of the full range of said linear dynamic range through to said final digital video output.

15

11. A video camera system, comprising:

an imaging device with an analog video output having a linear dynamic range;

20 a variable amplifier connected to adjust the analog gain of said analog video output and to produce an amplified analog video signal;

25 an analog-to-digital converter (ADC) connected to receive said amplified analog video signal and for providing a digital conversion in which said linear dynamic range of the imaging device is fully preserved through to a digital video output; and

30 a digital translation table connected to receive said digital video output and providing for an output conversion in which at least three different linear digital gains are applied to said linear dynamic range of the imaging device, and having a final digital video output;

wherein, a highest-gain one of said three different linear digital gains is used to help render image details

more clearly that would otherwise be lost to view in any other lower-gain portions of a video image frame.

12. The system of claim 11, wherein:

5                   the digital translation table in which a multi-slope output conversion includes at least two knee-points that join said different linear digital gains.

ABSTRACT OF THE DISCLOSURE

A CCD video camera system comprises a CCD imaging device connected to a low-gain amplifier. An analog-to-digital converter converts the analog output of the amplifier to a full-range digital video signal. Such addresses a digital look-up table to produce a digital video output according to one of several selectable range-correction curves. Such range-correction curves comprise two linear slopes that join at a knee, and the two linear parts have two different gain slopes. The range-correction curves are selected on the basis of the gain slope of the first of the two linear slopes, and the knee-point.

Fig. 1

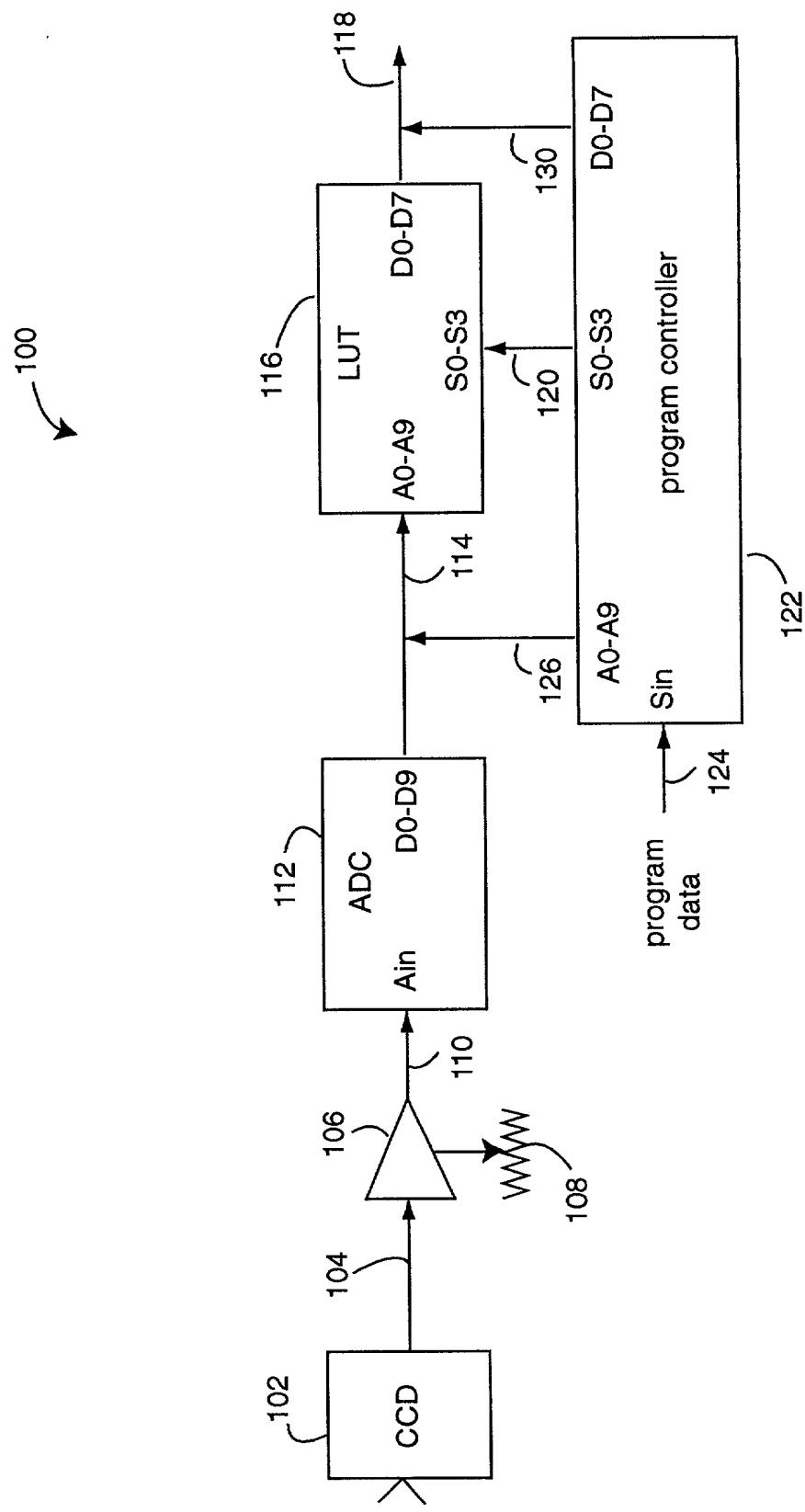
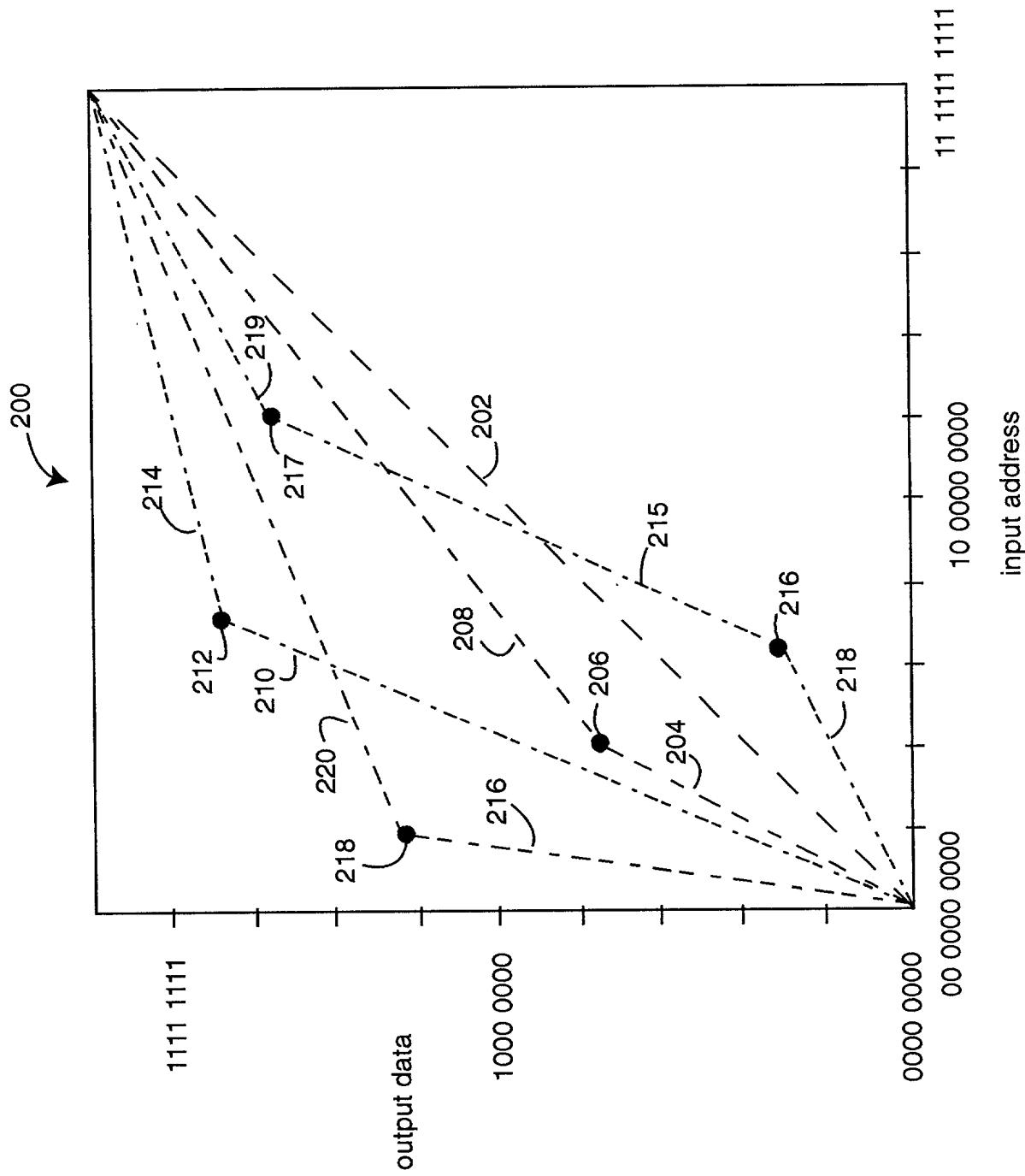


Fig. 2



## **DECLARATION**

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

### **VIDEO GLARE REDUCTION**

the specification of which

is attached hereto.

was filed on \_\_\_\_\_ as Application Serial  
No. \_\_\_\_\_ and was amended on \_\_\_\_\_  
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37, Code of Federal Regulations, §1.56 and which is material to the examination of this application, namely, information where there is a substantial likelihood that a reasonable examiner would consider it important in deciding whether to allow the application to issue as a patent

and in compliance with this duty there is attached an information disclosure statement in accordance with 37 CFR 1.98.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international applications(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed;

no such applications have been filed.

such applications have been filed as follows.

A. Prior Foreign/PCT Application(s) filed within 12 months  
(6 months for Design) prior to this Application  
and any Priority Claims under 35 U.S.C. §119:

#### Priority Claimed

(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
<input type="checkbox"/>				
<input type="checkbox"/>				

Continued -

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter to each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

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(Application Serial No.)

(Filing Date)

(Status: patented,  
pending, abandoned)

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(Application Serial No.)

(Filing Date)

(Status: patented,  
pending, abandoned)

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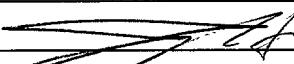
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Address all telephone calls to Thomas E. Schatzel at telephone No.  
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of  
sole or first inventor: TOSHIKAZU (NMI) HORI

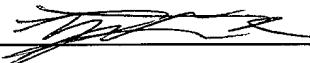
Inventor's Signature:  Date: 7/20/00

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Continued --

Full name of  
third joint inventor: RAYMOND J. SIU

Third Inventor's Signature: Raymond J. Siu Date: 4/20/00

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Citizenship: United States

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Attny. Docket No. SS-722-07

**POWER OF ATTORNEY BY ASSIGNEE**

The undersigned, as Assignee of the entire right, title, and interest in and to the subject matter which is described and claimed and for which a patent is sought on the invention entitled:

**VIDEO GLARE REDUCTION**

the specification of which

X is attached hereto;

       was filed on \_\_\_\_\_ as Application Serial No. \_\_\_\_\_  
and was amended on \_\_\_\_\_;  
(if applicable)

       Assignment recorded on \_\_\_\_\_ at Reel/Frame \_\_\_\_\_  
(if applicable)

hereby elects to control the prosecution of this application and hereby appoints the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office in connection therewith:

**Thomas E. Schatzel      Reg. No. 22,611**

Address all correspondence to:

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A Professional Corporation  
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Los Gatos, California 95032-2547

Address all telephone calls to **Thomas E. Schatzel** at telephone No. **(408) 358-7733**.  
Our facsimile No. **(408) 358-7720**.

Assignee hereby petitions and requests that this file be closed to the inventor(s), or representative(s) thereof.

PULNIX AMERICA, INC.

Dated: 4/20/2000

By   
TOSHIKAZU (NMI) HORI

Title: PRESIDENT

PULNIX AMERICA, INC.  
1330 Orleans Drive  
Sunnyvale, California 94089